Convective Influence on TTL Composition

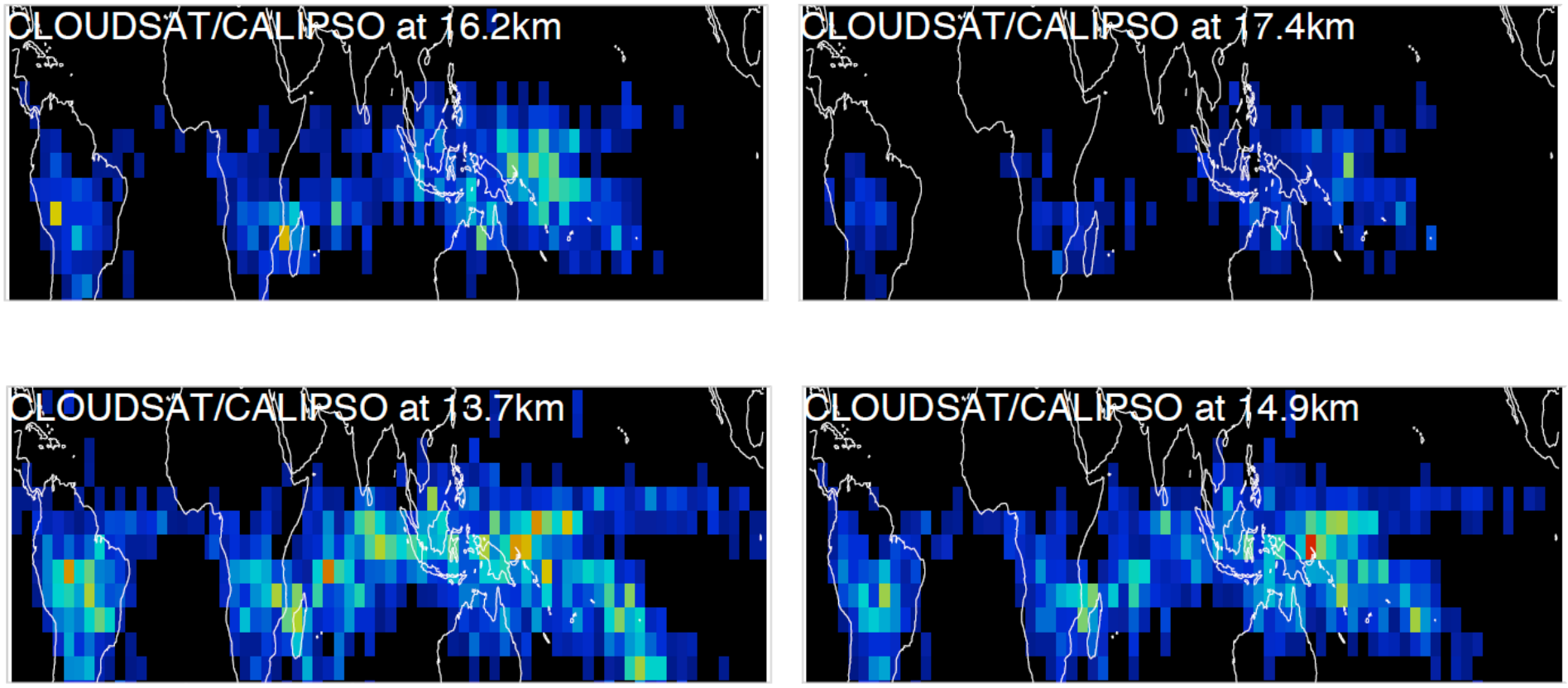
L. Pfister

Convection is the dominant energy source for tropical dynamics. It drives the vertical circulation up to the main outflow level (10-13 km), and contributes strongly (via wave driving) to it up to 16-18 km.

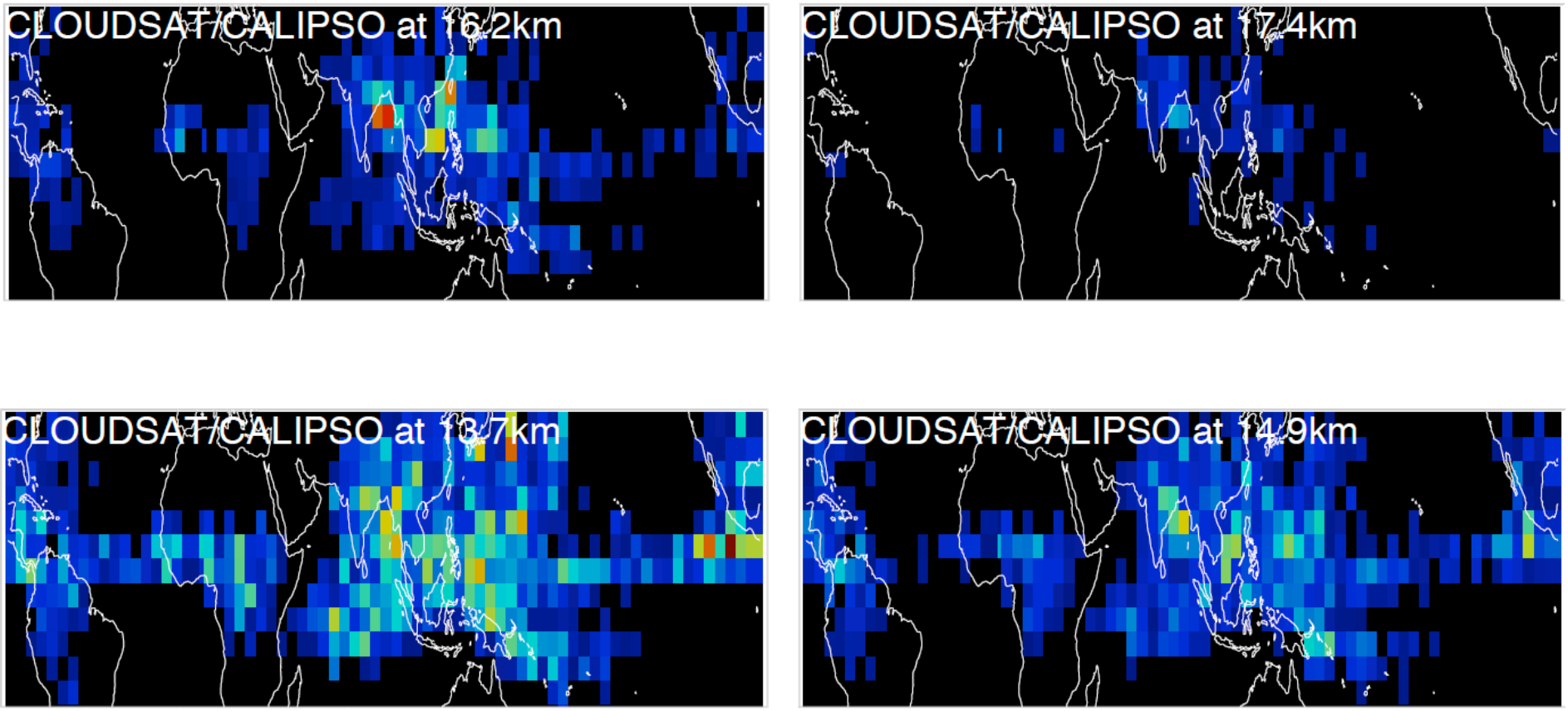
Outline

- Distribution of convection (specifically cloud tops from convection) for the two seasons in which we will be flying (CLOUDSAT observations)
- Relationship of convection to mean heating/vertical motion in the TTL.
- Effects on composition from model calculations
- Effects on water vapor (model calculations)

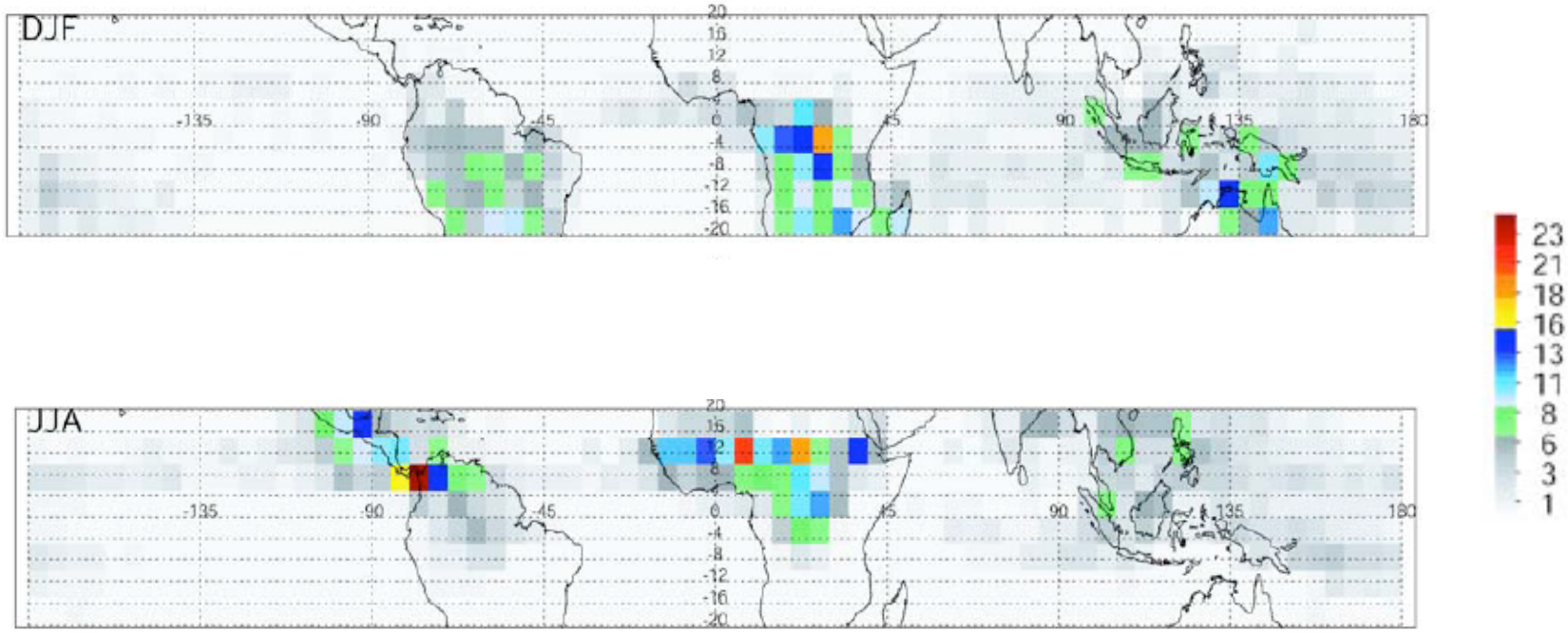
Winter Season (DJF, 2006-2007) Convective Cloud Top Incidence per km



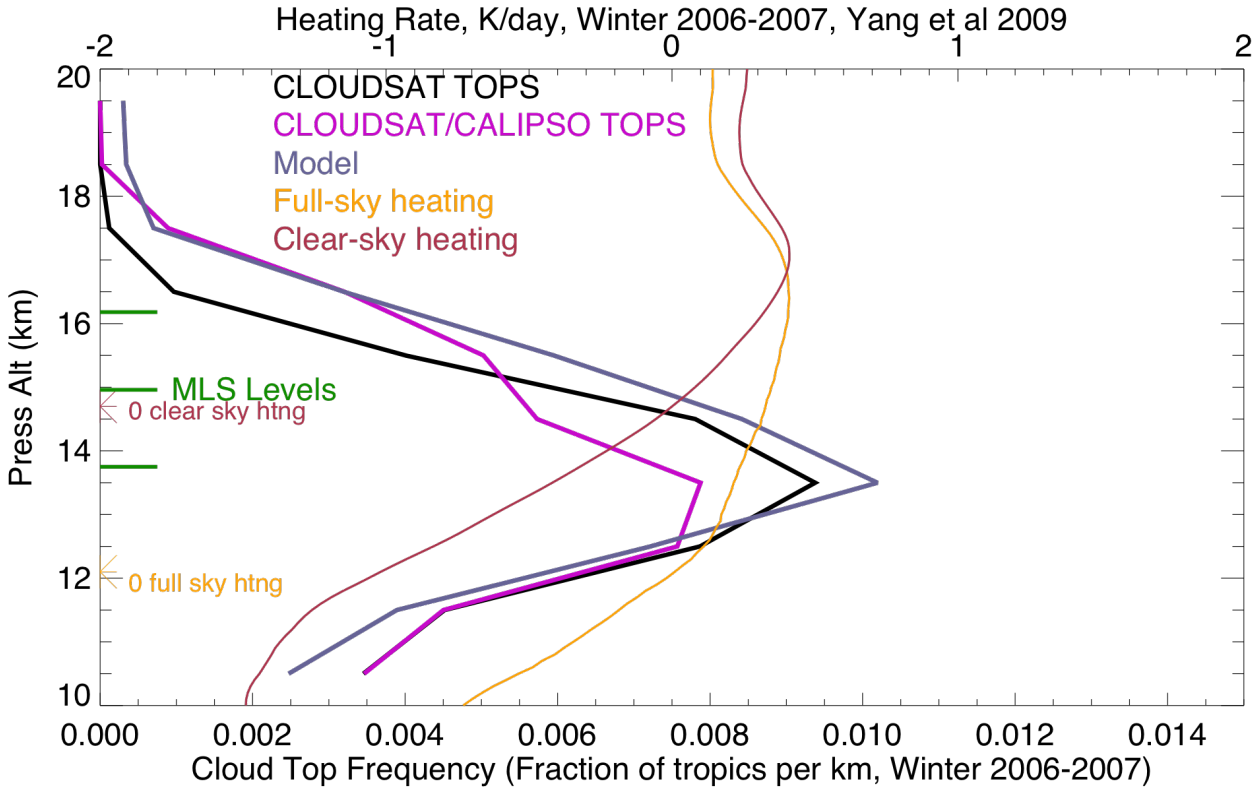
July-August 2007 convective cloud top incidence



Fraction of pixels with overshooting precipitation
above 14 km from TRMM, parts per thousand



Altitude of convection in relationship to large scale vertical motion



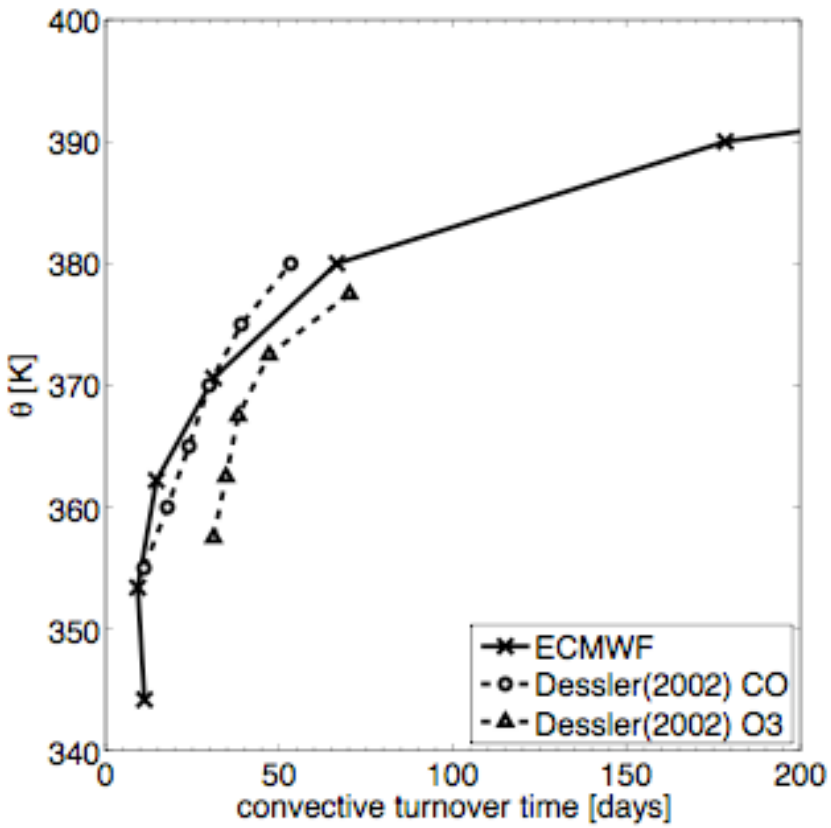
Convective cloud top incidence maximizes at about 13.5 km in the winter -10 to 10 degree tropics

Ability of convective injection to directly influence the stratosphere depends on level of 0 radiative heating.

Note that even with clear sky heating, a significant portion of convection has tops above the 0 level.

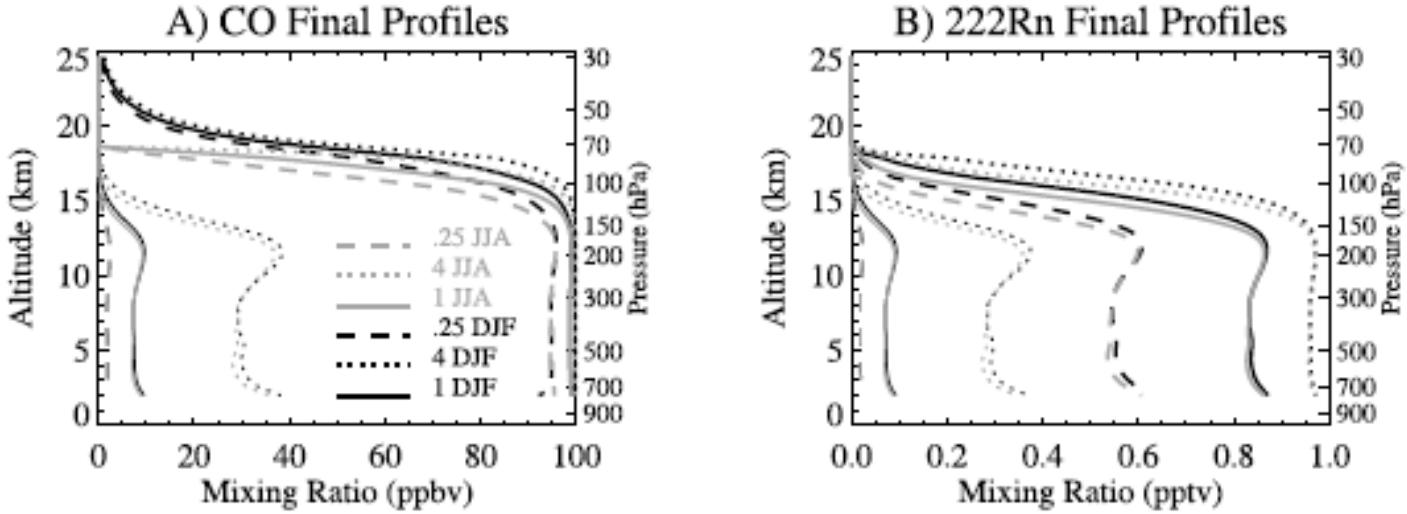
Caveats – CLOUDSAT/CALIPSO misses some of the deepest diurnal land-based convection. Tops of clouds are not pure tropospheric air

Level of uncertainty in convective turnover times is substantial



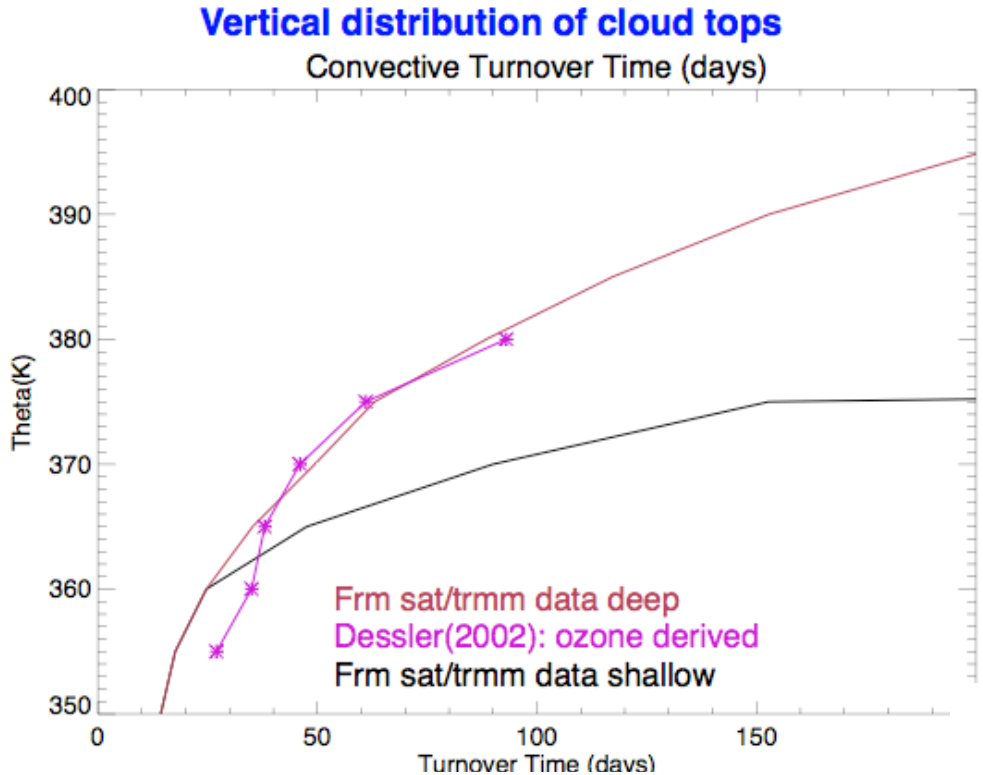
Note also that the times in the lower TTL are a week or more,
compatible with the tracers WAS measures (lifetimes of a week or more).

Model results show the effect of this uncertainty

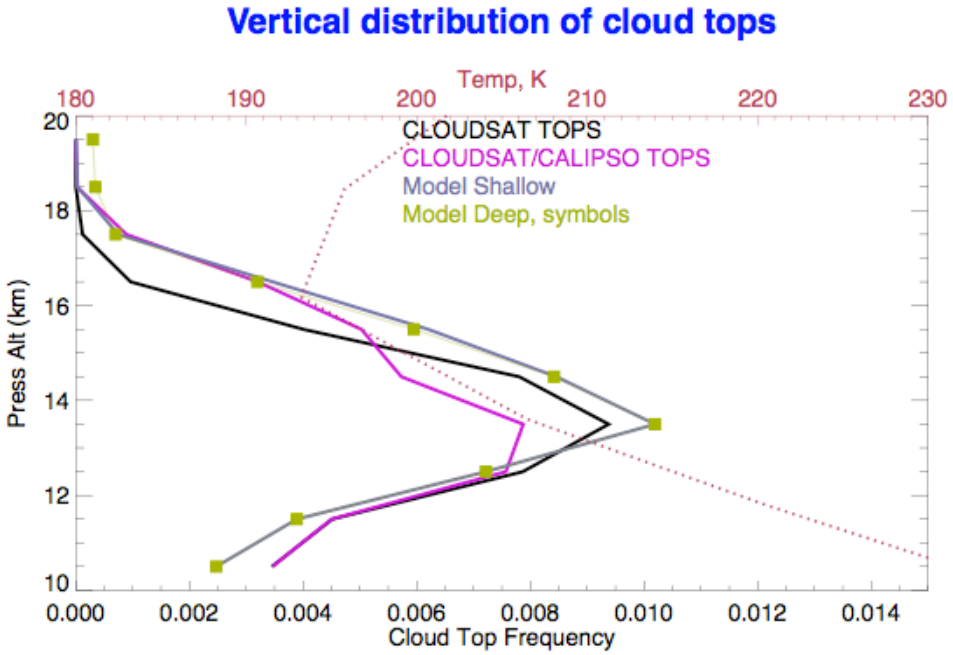


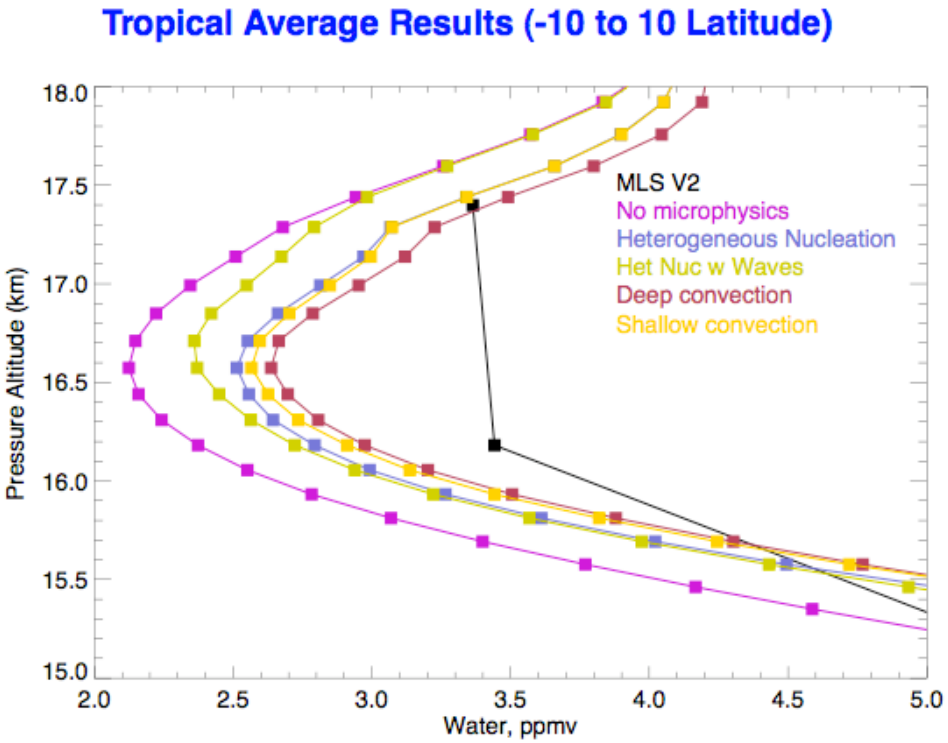
Lifted from Gettelman's paper – 1-D model that includes vertical advection (EC analyses), convective injection, chemical loss, and mixing with midlatitudes.

The above shows results for a long-lived tracer (CO – 60 days), and a short-lived one (radon – 1-2 days). Even for CO, varying convective inputs (given current uncertainties) has a substantial effect.



Using a convective injection scheme in our microphysical model consistent with vertical distributions from Cloudsat and Dessler's mixing times, come up with a fairly small effect due to convection (winter season)





Science questions and measurement requirements

- What is the "convective turnover time" in the TTL?
- How important is convective injection relative to other mechanisms as a function of altitude?

  (or location?
- Needed – measurements of tracers with varying lifetimes. Since turnover times in the TTL (we think) are several weeks, one week lifetime tracers will be useful.

Summary

- Maximum in incidence of convective cloud top altitudes is at about 13.5 km (150mb), consistent with current thinking of max detrainment at 10-13 km.
- Significant incidence above this level (within the TTL – stabilization layer at 150mb.
- Significant uncertainty in convective detrainment distribution, and its relationship to the large scale vertical motion